Schlumberger ITS 9000*PX/MX* Subroutine Memory Option

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Preface

Overview

The Subroutine Memory is an option provided for the Schlumberger ITS 9000*PX/MX* for test situations that require the execution of repetitive codes or conditional loops to ensure the device being tested is in a know state. The test data can be sourced from the either the Subroutine Memory itself or the Main Memory.

The test vectors are written in a similar way to those of the Main Memory. An additional set of Subroutine Memory specific instructions are provided to simplify complex test needs.

The Subroutine Memory has 4K memory capacity depth.

Intended Audience

This publication should be used by anyone using the Schlumberger ITS 9000*PX/MX* Subroutine Memory option.

Terms and Abbreviations

The following table lists the terms and abbreviations used in this publication.

Table 0.1 List of Terms and Abbreviations

Term/Abbreviation	Meaning
APG	Algorithmic Pattern Generator
ASAP	Advanced Symbolic ATE Programing
DPS	Device Power Supply
ESS	Event Sequence Store.
ESSM	Event Start Sequence Memory.
Left Click	Click on an item with the left-hand mouse button.
MSCM	Main Sequence Control Memory.
PE	Pin Electronics

Table 0.1 List of Terms and Abbreviations

Term/Abbreviation	Meaning
PMU	Precision Measurement Unit
TBD	To Be Defined.

Conventions

The following table lists the conventions used in this user guide to illustrate certain points.

Table 0.2 List of Conventions

Convention	Meaning
UPPERCASE	Any command in UPPERCASE must be typed on the system exactly as it is shown in the manual.
lower case	Any procedure parameter in lower case is to be replaced by a user input required.
[parameter]	Any procedure parameter enclosed in square brackets is optional. In the case of confusion with a required square bracket a comment is added.
<USER_INPUT>	User supplied data is indicated by placing its name within <>.
{comment}	Braces enclose explanatory comments, and are generally used in examples.
Hex 0F13	A number preceded by the letters ‘Hex’ is in hexadecimal notation.
Bin 1010	A number preceded by the letters ‘Bin’ is in binary notation.
…	An ellipsis means that either the preceding item can be repeated, or that lines of a program are supplied by you, depending on the specific needs of that program.

Related Publications

The following publications provide additional information for some of the topics covered by this manual. Whenever such information is available a reference to the related publication is given in the text of this publication.

Table 0.3 List of Related Publications

Part Number	Title
740018905	Schlumberger ITS 9000*PX/MX* Algorithmic Pattern Generator User Guide.
740018030	Schlumberger ITS 9000*PX/MX* Diagnostic Manual

Installation

This section describes the hardware and software installation procedures for the Schlumberger ITS 9000*PX/MX* Subroutine Memory option.

1.1 Prerequisites

Your Schlumberger ITS 9000*PX/MX* must have the following hardware and software configurations.

1.1.1 Hardware

Not Applicable

1.1.2 Software

The Schlumberger ITS 9000*PX/MX* must be running ASAP software version 2.x or later.

1.2 Hardware Installation

The hardware installation of the Subroutine Memory may only be carried out by Schlumberger Technologies Field Service personnel.

The following table lists the hardware items required for the Subroutine Memory Option and their crate locations:

Table 1.1 Subroutine Memory Hardware Installation

	Description	C-Crate	H-Crate
1	Sub Sequence Instruction Decoder	✔	
2	MSCM 4M	✔	
2	Subroutine Memory	✔	
1	CM Sub Address	✔	
1	Subroutine Memory Data Multiplexer per 32 Pins		✔

1.2.1 Subroutine Memory Card Locations in the C-Crate

The following illustration shows the locations of the Subroutine Memory option cards in the C-Crate:

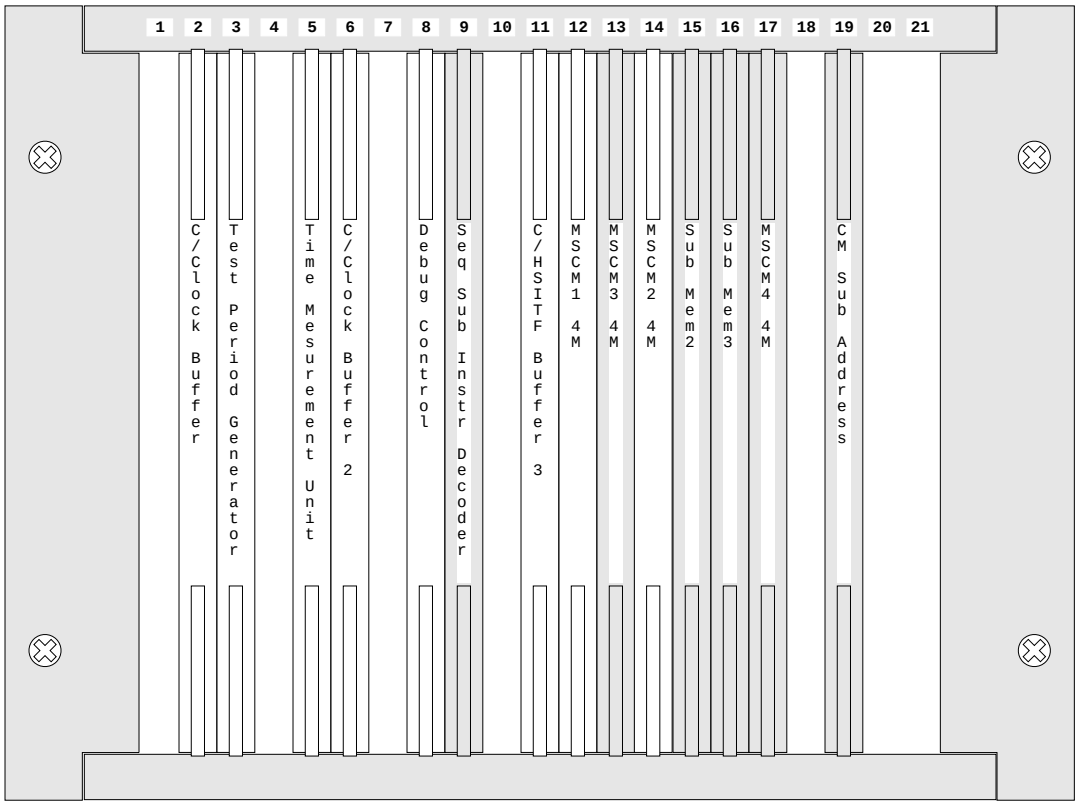

Figure 1.1 Subroutine Memory Card Installation in the C-Crate

1.2.2 Subroutine Memory Card Locations in the H-Crate

The following illustration shows the locations of the Subroutine Memory option cards in the H-Crate:

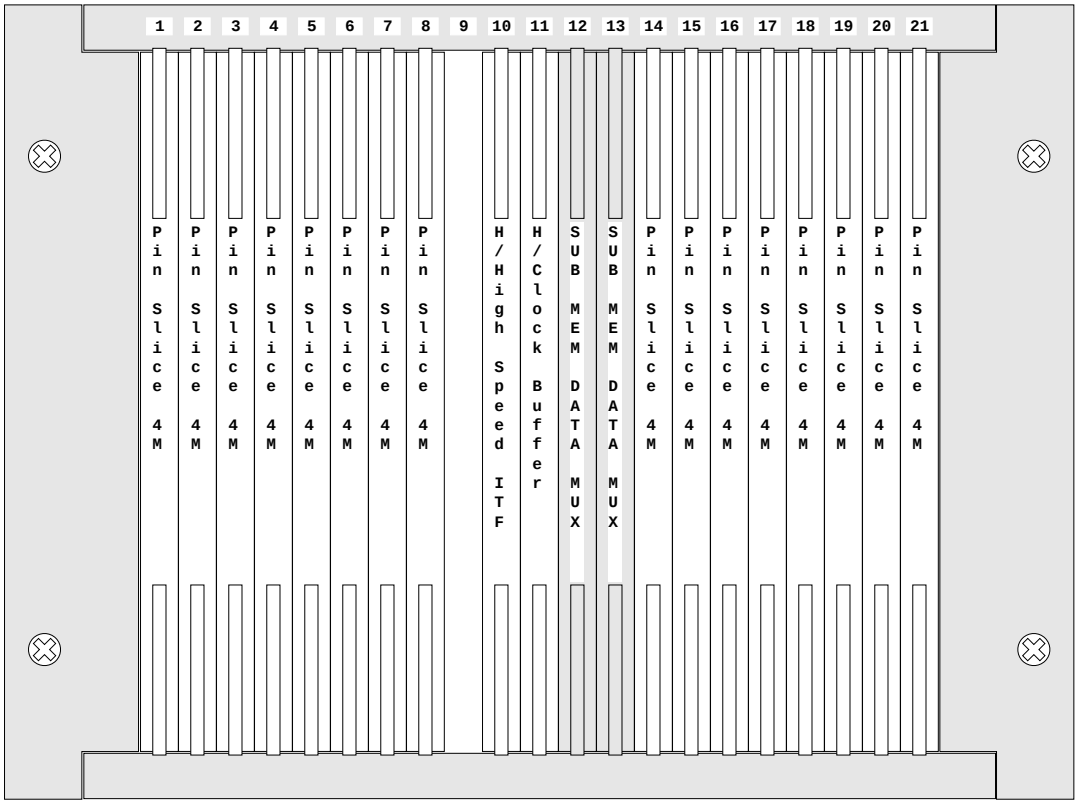

Figure 1.2 Subroutine Memory Card Installation in the H-Crate

1.3 Software Installation

The software for the Subroutine Memory Option is included with the standard Schlumberger ITS 9000*PX/MX* Test System software.

1.4 Testing

To test the Subroutine Memory run the Schlumberger ITS 9000*PX/MX* diagnostics[1].

1 The diagnostics are described in the Schlumberger ITS 9000*PX/MX* Diagnostics Manual.

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Subroutine Memory Programming

2.1 Subroutine Structure

The format of a Subroutine Memory programing line is written as follows:

Format:

```
SUBROUTINE_F;
[<LABEL>] <INSTRUCTION> [<OPERAND>] [<LOPM>] [<+>] [<SCAN>]
[<EINSTn>]
<VEC_DEF> {<F_DATA>)
```

Parameters:

Table 2.1 lists the parameters of the subroutine structure.

Table 2.1 Subroutine Memory Parameters

Parameter	Description
<LABEL>	The <LABEL> is used by certain instructions, e.g. CALL, GOTO, GONZ, etc. to identify branch addresses.
<INSTRUCTION>	The <INSTRUCTION> controls the Subroutine sequencer.
<OPERAND>	The <OPERAND> is an optional field for the instructions that require an address or count.
<+>	The <+> instruction token increments the parameter vector.
<SCAN>	The <SCAN> instruction token increments the serial scan vector.
<EINSTn>	The <EINSTn> instruction token enables the Instrument <n>.
<VEC_DEF>	The <VEC_DEF> defines the combination of sequence names the Pindefs use.

Table 2.1 Subroutine Memory Parameters

Parameter	Description
<F_DATA>	The <F_DATA> field contains the actual vector for the line, and is written in the same order as the Pindef.

Note: The Subroutine Memory Option provides four additional Enable Instrument bits.

2.1.1 Operand Size Selection

Without the Subroutine Memory option installed the range of values of the operand can be from 2 - 4096 (12-bit operand). With the Subroutine Memory option installed this range is increased to 2 - 65536 (16-bit operand).

By default the 12-bit operand is used. In order to select the 16-bit operand the `OPERAND_16_BITS` directive must be specified on the line following the `#pattern pattern_name` directive in the pattern file.

2.2 Subroutine Memory Instructions

The Subroutine Memory instructions are of the following categories: incremental, branching, loading, and control.

Table 2.2 lists the Subroutine Memory Instructions.

Table 2.2 Subroutine Memory Instructions

Syntax	Opcode	Instruction Description	Applicability	
			Subroutine Memory	Main Memory
INC	0000	Increment	4	4
HALT	0001	Halt	4	4
LDCH	0010	Load Loop Counter (Conditional)	4	4
LDC	0011	Load Loop Counter	4	4
RPTM	0100	Repeat Until Match	4	4
RPT	0101	Repeat	4	4
RPTC	0110	Repeat Continuous	4	4
CALLM	1000	Call Match Subroutine		4
CALLZ	1001	Call (Loop) Subroutine	4	4

Table 2.2 Subroutine Memory Instructions (Continued)

Syntax	Opcode	Instruction Description	Applicability	
			Subroutine Memory	Main Memory
CALLC	1010	Call Continuous Subroutine	4	4
CALL	1011	Call Subroutine	4	4
GONZ	1100	Go On Not Zero to Subroutine	4	
GOTO	1101	Goto Subroutine	4	
GOCL	1110	Go Continuous to Subroutine	4	
RET	1111	Return from Subroutine	4	

2.2.1 INC (Increment) Instruction

The INC instruction executes the current line and increments the Program Counter (PC).

Format:

```
INC [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC           VEC_DEF     {001101}
```

2.2.2 HALT Instruction

The HALT instruction executes the current line and ends the execution sequence.

Format:

```
HALT [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
...
...
HALT          VEC_DEF     {001010}
```

2.2.3 RET (Return from Subroutine) Instruction

The RET instruction executes the current line and returns to the line following the last calling instruction. This return can be to either to the Main or Subroutine Memory depending on where the last call was made from.

Format:

```
RET <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
...
...
RET, LABEL     VEC_DEF     {001010}
```

2.2.4 RPT (Repeat) Instruction

The RPT instruction executes the current line <n> times and increments the Program Counter (PC).

Format:

```
RPT, n [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC            VEC_DEF     {001010}
RPT, 6         VEC_DEF     {111010}
```

2.2.5 RPTM (Repeat Until Match) Instruction

The RPTM instruction either executes the current line until a match condition is found and increments the Program Counter (PC) or executes the current line n times, ends the execution sequence and returns an error message (Debug Mode) if the match is not found.

Format:

```
RPTM, n [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC            VEC_DEF     {001010}
RPTM, 6        VEC_DEF     {111010}
```

2.2.6 RPTC (Repeat Continuous) Instruction

The RPTC instruction executes the current in a continuous loop and sends an interrupt signal to the CPU to allow the CPU to execute the next Test Program instruction whilst the functional test is looping.

There are two methods of stopping the continuous loop, these are:

- A KILL instruction in the Test Program stops the continuous loop and executes the next instruction of the Test Program in a DC test.
- A RESUME instruction in the Test Program stops the continuous loop and executes the next instruction of the functional sequence in a DC or functional test.

Format:

```
RPTC [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC             VEC_DEF     {001010}
RPTC            VEC_DEF     {100110}
```

2.2.7 CALL (Call Loop Subroutine) Instruction

The CALL instruction can be made from the Main or Subroutine.

From the Main the CALL instruction starts the following sequence:

- Executes the current line.
- Increments the Program Counter (PC) and jumps to the subroutine address corresponding to the associated label.
- Executes the instructions at this address until a RET instruction is encountered.

The next instruction following the CALL is then ready to be executed.

From the subroutine the CALL instruction starts the following sequence:

- Executes the current line.
- Increments the Program Counter (PC) and jumps to the subroutine address corresponding to the associated label.
- Increments the Subroutine address and jumps to the subroutine address corresponding to the associated label.
- Executes the instructions at this address until a RET instruction is encountered.

The next instruction following the CALL in the subroutine is then ready to be executed.

Up to a maximum of 16 nested CALL instructions can be used at the same.

Format:

```
CALL, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
MAIN_F;
INC                         VEC_DEF     {001010}
CALL,           LABEL1      VEC_DEF     {101011}
...
...

SUBROUTINE_F;
LABEL1;
INC                         VEC_DEF     {111011}
...
...
RET,            LABEL1      VEC_DEF     {001110}
```

2.2.8 CALLZ Instruction

The CALLZ instruction starts the following sequence:

- Executes the current line.
- Increments the Program Counter (PC) and jumps to the address corresponding to the associated label.
- Executes the instructions at this address in a loop until the RET instruction has been encountered the number of times corresponding to the value defined with the LDC instruction[1].

The next instruction following the CALL is then ready to be executed.

Format:

```
CALLZ, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

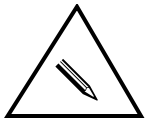
```
MAIN_F;
INC                         VEC_DEF     {001010}
LDC,2                       VEC_DEF     {011010}
CALLZ,          LABEL1      VEC_DEF     {101011}
...
...

SUBROUTINE_F;
LABEL1;
INC                         VEC_DEF     {111011}
LABEL2;
...
...
RET, LABEL2                 VEC_DEF     {001110}
```

2.2.9 CALLC (Call Continuous Subroutine) Instruction

The CALLC instruction starts the following sequence:

- Executes the current line.
- Increments the Program Counter (PC) and jumps to the address corresponding to the associated label.
- Executes the instructions at this address in a continuous loop and sends an interrupt signal to the CPU to allow the execution of the next Test Program instruction whilst the functional test is looping.



Note: The CALLC instruction cannot be used within a loop already initiated with another CALLC instruction.

There are two methods of stopping the continuous loop, these are:

1 The LDC Instruction is described in section 2.2.14 “LDC (Load Loop Counter) Instruction” on page 2-9 of this User Guide.

- A KILL instruction in the Test Program stops the continuous loop and executes the next instruction of the Test Program in a DC test.
- A RESUME instruction in the Test Program stops the continuous loop and executes the next instruction of the functional sequence in a DC or functional test.

Note: When the loop is stopped with RESUME instruction in the Test Program the execution of the current loop continues until the end of the loop. If a GOTO instruction is included in the loop the KILL instruction must be used to stop the loop.

Format:

```
CALLC, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
MAIN_F;
INC                         VEC_DEF     {001010}
CALLC,          LABEL1      VEC_DEF     {101011}
...
...

SUBROUTINE_F;
LABEL1;
INC                         VEC_DEF     {111011}
...
...
RET, LABEL                  VEC_DEF     {001110}
```

2.2.10 CALLM (Call Match Subroutine) Instruction

The CALLM instruction starts the following sequence:

- Executes the current line.
- Increments the Program Counter (PC) and jumps to the address corresponding to the associated label.
- Executes the instructions at this address until a match condition is found.

The next instruction following the CALL is then ready to be executed.

If the match is found the next instruction following the CALLM is then ready to be executed.

If the match condition has not been found in the number of loops corresponding to the value defined with the LDC instruction the execution sequence ends and an error message is returned (Debug Mode).

Format:

```
CALLM, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
MAIN_F;
INC                         VEC_DEF     {001010}
LDC,20                      VEC_DEF     {011010}
CALLM,          LABEL1      VEC_DEF     {101011}
...
...

SUBROUTINE_F;
LABEL1;
INC                         VEC_DEF     {111011}
...
...
RET, LABEL                  VEC_DEF     {001110}
```

2.2.11 GOTO (Goto Subroutine Location) Instruction

The GOTO instruction executes the current line and makes an unconditional jump to address corresponding to the <LABEL>. The next instruction following this <LABEL> is then ready to be executed.

Format:

```
GOTO, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC                         VEC_DEF     {001010}
GOTO,           LABEL1      VEC_DEF     {101011}
...
...

LABEL1;
INC                         VEC_DEF     {111011}
...
...
```

2.2.12 GONZ (Go on Not Zero to Subroutine Location) Instruction

The GONZ instruction executes the current line, makes a conditional jump to address corresponding to the <LABEL>and executes the instructions until the counter loaded with the LDC instruction equals zero. Once the counter equals zero the next instruction following this GONZ instruction is ready to be executed.

Format:

```
GONZ, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC                         VEC_DEF     {001010}
LDC,3                       VEC_DEF     {011010}
LABEL1;
INC                         VEC_DEF     {001110}
INC                         VEC_DEF     {101010}
GONZ,           LABEL1      VEC_DEF     {101011}
...
...
```

2.2.13 GOCL (Go Continuous to Subroutine Location) Instruction

The GOCL instruction starts the following sequence:

- Executes the current line.
- Makes an unconditional jump to the address corresponding to the <LABEL>.
- Executes the instructions at this address in a continuous loop and sends an interrupt signal to the CPU to allow the execution of the next Test Program instruction whilst the functional test is looping.

There are two methods of stopping the continuous loop, these are:

- A KILL instruction in the Test Program stops the continuous loop and executes the next instruction of the Test Program in a DC test.
- A RESUME instruction in the Test Program stops the continuous loop and executes the next instruction of the functional sequence in a DC or functional test.

Note: The GOCL instruction cannot be used within a loop already initiated with a CALLC instruction.

Format:

```
GOCL, <LABEL> [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC                         VEC_DEF     {001010}
LABEL1;
INC                         VEC_DEF     {001110}
GOCL,           LABEL1      VEC_DEF     {101011}
...
...
```

2.2.14 LDC (Load Loop Counter) Instruction

The LDC instruction executes the current line and loads the counter with the value specified with the operand< n>. The value specified must be less than 65536. This value is used to specify the number of loops that will be carried out by the following instructions. The counter is backed up with a 16 level stack. When the counter is loaded with the LDC instruction the previous count is ‘pushed’ onto the stack. When the loop that is actually using the counter has finished, the previous count is ‘popped’ off the stack back onto the counter.

This instruction must be used with the following instructions: GONZ, CALLZ and CALLM.

Format:

```
LDC,n [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC                         VEC_DEF     {001010}
LDC,3                       VEC_DEF     {011010}
LABEL1;
INC                         VEC_DEF     {001110}
INC                         VEC_DEF     {101010}
GONZ,           LABEL1      VEC_DEF     {101011}
...
...
```

2.2.15 LDCH (Load Loop Counter Conditional) Instruction

The LDCH instruction has the same function as the LDC instruction described above except that the counter is not loaded if the LDCH instruction is found at the step following a GONZ or RET instruction in a loop that has not finished.

Format:

```
LDCH,n [INSTRUCTION TOKENS] <VEC_DEF> {<F_DATA>}
```

Example:

```
SUBROUTINE_F;
INC                         VEC_DEF     {001010}
LDC,2                       VEC_DEF     {011010)
LABEL1;
INC                         VEC_DEF     {111010)
LABEL2;
LDCH,4                      VEC_DEF     {011010)
INC                         VEC_DEF     {001110)
INC                         VEC_DEF     {101111)
GONZ,           LABEL2      VEC_DEF     {101011)
GONZ,           LABEL1      VEC_DEF     {111011)
...
...
```

2.3 Parameter Passing

The F_Data for the Subroutine Memory can be sourced from either the Subroutine Memory or the Main Memory. The selection of the source of the F_Data is made using a Parameter Select directive. Up to a maximum of 256 Main/Sub Memory F_Data source selection combinations can be used. Figure 2.1 shows an example of parameter passing.

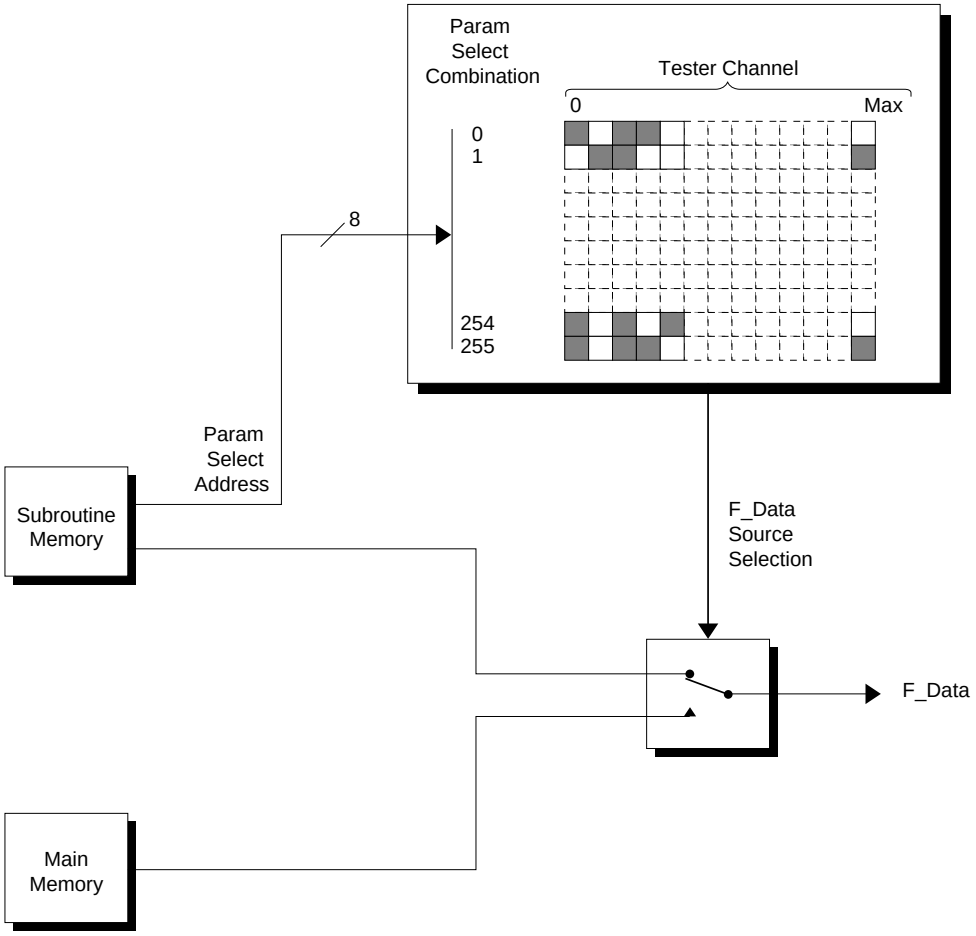


Figure 2.1 F_Data Source Selection Block Diagram

The source of the F_Data for each PINDEF is identified in the test vector as follows:

- A value written according to the PINDEF radix represents the F_Data for this PINDEF in the Subroutine Memory.
- An '=' sign signifies the Main Memory is the source of the F_data for the PINDEF. This F_Data is sourced from the relevant PINDEF position in the Main Memory using a PARAM instruction token.

If the same F_Data is required to be sourced from the Main Memory regardless of the parameter select combination used in the Subroutine Memory only a single PARAM instruction token needs to be used in the Main Memory.

If the different F_Data is required to be sourced from the Main Memory regardless of the parameter select combination used in the Subroutine Memory the same number of PARAM instruction tokens need to be used in the Main Memory as the number of different F_Data combinations required. To use this different F_Data the Main Memory must be incremented to point to the correct PARAM instruction token. To do this a '+' instruction token must be placed before the F_Data definition in the subroutine.

Example

The following example shows the parameter passing interaction between the Main and Subroutine Memories.

Table 2.3 Main Memory

Line		Description
M1	`MAIN_F`	
M2	`INC VEC_DEF (001011)`	Execute current line and increment the Program Counter.
M3	`CALL, LABEL VEC_DEF (101011)`	Jump to `LABEL1` in the Subroutine (Line S2)
M4	`PARAM (101001)`	Param vector
M5	`PARAM (111011)`	Param vector
M6	`HALT VEC_DEF (111011)`	

Table 2.4 Subroutine Memory

Line	Vector	Description
S1	`SUBROUTINE_F`	
S2	`LABEL1;`	
S3	`INC, VEC_DEF (111011)`	Execute current line and increment Subroutine address
S4	`INC, VEC_DEF (1010=1)`	Execute current line and increment Subroutine address. The = symbol indicates the F-data is sourced from the Main (Line M4)
S5	`INC, + VEC_DEF (1=10=1)`	Execute current line and increment Subroutine address. The = symbol indicates the `F_data` is sourced from the Main (Line M4). The + symbol increments the Main PC (to line M5)

Table 2.4 Subroutine Memory (Continued)

Line	Vector	Description
S6	`INC,  + VEC_DEF  (1110=1)`	Execute current line and increment Subroutine address. The = symbol indicates the F-data is sourced from the Main (Line M5). The + symbol increments the Main PC (to line M6)
S7	`HALT  VEC_DEF  (100011)`	Executes current line and returns to line M6

2.4 Match Modes

The Schlumberger ITS 9000*PX/MX* provides two types of Match Mode that are used to ensure that t the DUT is in known state during the functional test. These three match modes are:

- ❏ Fast
- ❏ Immediate

The match modes can either be executed with the `RPTM` instruction in the Subroutine Memory or the Main Memory, or executed using the `CALLM` instruction from the Main Memory to initiate a loop match sequence in the Subroutine Memory.

Regardless of the match mode or instruction (`RPTM` or `CALLM`) being used the match `SEQUENCE` must be first defined. This sequence can contain up to 16 consecutive PASS/ FAIL match conditions, e.g. `SEQUENCE = PFP,` meaning the match loop will complete when a PASS-FAIL-PASS condition is found. Once the match `SEQUENCE` has been defined it will be used for all match vectors within the same pattern.

2.4.1 Fast Match Mode

Using the fast match mode, once the match condition is found the pipeline must first be emptied before executing the instruction following the `RPTM` or `CALLM` instruction. The minimum length of the pipeline depends on the period value the match vector uses. The pipeline length (Pipe) expressed in steps must be calculated as follows:

$$\mathbf{PIPE} \geq \mathbf{15} + \left(\frac{\mathbf{400ns}}{\mathbf{Match\ Period}} \right) \qquad \text{Eqn. 2.1}$$

The fast match mode by default uses the same match sequence for **`ALL`** matching. If the **`ONE_SHOT`** parameter is used, the predefined match `SEQUENCE` will be used for the first match vector executed and all the following match vectors will only use the match `SEQUENCE = PASS`.

2.4.2 Immediate Match Mode

The immediate match mode can only be used when the delay between the last edge of match vector strobe and the end of the period is > 1.1 µs. It is not therefore necessary to calculate the pipeline length because the system has time to empty the pipeline before executing the instruction following the `RPTM.`

The immediate match mode by default uses the same match sequence for **`ALL`** matching. If the **`ONE_SHOT`** parameter is used, the predefined match `SEQUENCE` will be used for the first match vector executed and all the following match vectors will only use the match `SEQUENCE = PASS`.

2.4.3 Match Mode Programming

The match type must be defined before the `SUBROUTINE_F` or `MAIN_F` directives in the pattern source code.

The syntax for the match mode is as follows:

```
MATCH {MODE = FAST ALL, SEQUENCE = “PFPF”, PIPE = 35}
```

Where the `MODE` can be:

```
MODE = FAST   ALL         Default value
MODE = FAST               Default value is ALL
MODE = FAST   ONE_SHOT
MODE = IMMEDIATE  ALL     Default value
MODE = IMMEDIATE          Default value is ALL
MODE = IMMEDIATE  ONE_SHOT
```

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